

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
FOURTH SERIES

Vol. XXXVI, No. 16, pp. 501-510; 26 figs.

April 18, 1969

A NEW SUBSPECIES OF *BALANUS*
TINTINNABULUM (LINNAEUS, 1758)
(CIRRIPEDIA, THORACICA) FROM
CLIPPERTON ISLAND, EASTERN PACIFIC

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ABSTRACT: *Balanus* (*Megabalanus*) *tintinnabulum clippertonensis* Zullo, new subspecies, is the only barnacle known from Clipperton Island, an isolated atoll about 1100 kilometers off the coast of Mexico in the Eastern Pacific. The new subspecies is related to *B. tintinnabulum galapaganus* Pilsbry, 1916 from the Galápagos Archipelago and Cocos Island (Costa Rica), and to *B. tintinnabulum tanagrae* Pilsbry, 1928 from the Hawaiian Islands. Together, these subspecies form an insular complex apparently unrelated to West American subspecies of *B. tintinnabulum*.

INTRODUCTION

The barnacles described herein were collected in the littoral zone at Clipperton Island by Dr. Edwin C. Allison of San Diego State College, California on 24 October 1956 during investigations by the Scripps Institution of Oceanography. Clipperton Island, the only true atoll in the Eastern Pacific, is located about 1100 kilometers off the coast of Mexico. Its marine fauna, composed of a mixture of Indo-West Pacific and West American elements, has been of particular interest to marine biogeographers (Hertlein and Emerson, 1953, 1957; Hertlein and Allison, 1960).

Of the twenty-four specimens collected, only two were found alive. The entire lot represents a careful search of the intertidal and, by means of SCUBA, the subtidal to depths of 40 meters. In addition, subsequent examination of collected corals and other invertebrates for coralophilous and commensal bar-





nacles brought negative results. The single subspecies obtained is described as follows:

Family BALANIDAE Leach, 1817

Genus *Balanus* Da Costa, 1778

Subgenus *Megabalanus* Hoek, 1913

Balanus tintinnabulum clippertonensis Zullo, new subspecies.

(Figures 1-26.)

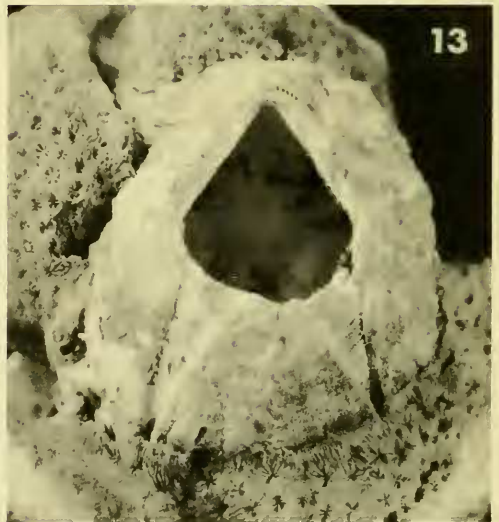
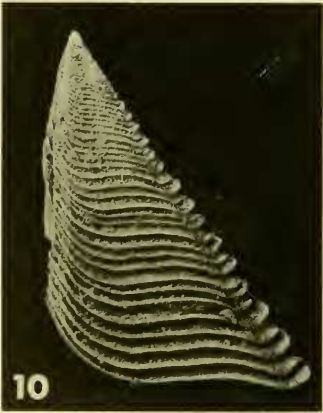
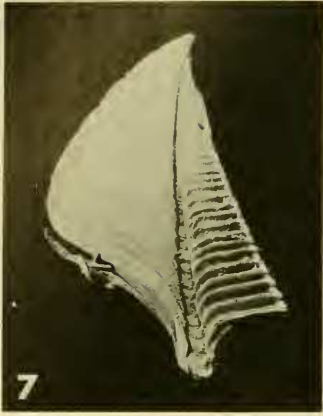
DESCRIPTION. Dimensions of holotype UCMP 10184: height, 9 millimeters; carinorostral diameter of orifice, 6 millimeters. Paratype CAS 13153: height, 11 millimeters; carinorostral diameter of base, 16 millimeters; carinorostral diameter of orifice, 8 millimeters. Paratype UCMP 10185: height, about 17 millimeters; carinorostral diameter of base, about 30 millimeters; carinorostral diameter of orifice, 13 millimeters (largest specimen).

Shell (figs. 8, 9, 12, 13) low conic with diamond shaped to subtrigonal orifice; parietes thick, irregularly roughened externally, colored moderate to pale pink or grayish red-purple, usually with indistinct, dark, longitudinal stripes on lighter background, especially noticeable on rostrum and rostromerals; parietal tubes small, numerous (20 in rostra of paratypes CAS 13153 and 13154), without transverse septa; interior of parietes white, with low ribs corresponding to parietal septa developed near base of parietes and fading towards sheath; sheath about one-half height of compartmental plates, colored grayish purple except for white alar regions, with deep, narrow space under lower edge; radii with tubes, relatively narrow, glossy, transversely striate, usually of lighter color, although occasionally of a darker purple than parietes; summits of radii horizontal; sutural edges of radii with well developed primary denticulae bearing secondary denticulae on both sides; alae wide with oblique summits; basis thin with numerous radiating tubes, thickening and becoming cancellate near edge.

Scutum (figs. 1, 4, 5, 10, 11) relatively narrow, basal margin one-half to two-thirds length of tergal margin; basitergal angle truncate parallel to occludent margin; tergal margin not reflexed; exterior of scutum tinged greyish pink, with darker band of moderate pink along occludent margin; exterior ornamented with distinct, closely spaced growth ridges, every other ridge forming tooth on

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FIGURES 1-6. *Balanus tintinnabulum clippertonensis* Zullo, new subspecies, Holotype UCMP 10184, UCMP locality B-4237, Clipperton Island. Figure 1, interior of scutum, height 5.5 millimeters; figure 2, interior of tergum, height 5 millimeters; figure 3, interior of tergum, height 5.5 millimeters; figure 4, interior of scutum, height 5.5 millimeters; figure 5, exterior of scutum of figure 4; figure 6, exterior of tergum of figure 3.



occludent margin; prominent, evenly arched articular ridge reflexed over deep, narrow articular furrow, occupying two-thirds to three-fourths of tergal margin, and terminating in blunt lobe; adductor ridge absent; lateral depressor pit small, deep, subcircular in outline; adductor muscle pit oval, well defined; interior of scutum white, calloused in upper half especially in area between adductor pit and tergal margin.

Tergum (figs. 2, 3, 6, 7) broad, white; basal margin forms slightly obtuse angle with tergal spur on both sides of spur; tergal spur narrow, short, placed about its own length, or from one to two times its own width from basiscutal angle; tergal furrow partially closed; exterior growth lines on carinal side of spur furrow fine and closely spaced, cut by indistinct radial striae; growth lines on scutal side produced into prominent, more widely spaced ridges; scutal margin reflexed greater than 90° , without prominent teeth; articular ridge not reflexed, slightly to moderately developed in upper half of tergum, becoming indistinct in lower half; articular furrow broad, shallow; lateral depressor crests indistinct; carinal side of interior noticeably calloused.

Labrum (fig. 15) deeply notched with three prominent teeth on crest on either side of notch; crest lined with fine hairs.

Palpi (fig. 16) densely clothed with setae on superior margin; longer less numerous setae line inner margin; a few setae situated on upper surface near and normal to inner margin.

Mandible (figs. 14, 22, 23) with four prominent teeth, not including inferior angle; first tooth largest; second tooth usually bifid, slightly larger than bifid third tooth; fourth tooth smaller, broader, with a few inconspicuous blunt accessory denticles on lower side; inferior angle with one to three denticles; uppermost denticle usually largest, having the appearance of an incipient fifth tooth; lowermost denticle armed with a pair of short spines; one or two pair of smaller spines may be present above lowermost denticle; inferior margin lined by long setae; anterior and posterior surfaces densely setose.

Cutting edge of *maxilla I* (figs. 17, 24) straight, or with lower third slightly protuberant; notch absent below upper two large spines; uppermost two spines largest on cutting edge, and followed by about seven shorter spines with spinules

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FIGURES 7-13. *Balanus tintinnabulum clippertonensis* Zullo, new subspecies, UCMP locality B-4237, Clipperton Island. Figure 7, exterior of tergum, height 6 millimeters; figure 8, basal view of shell with basis removed, carinorostral diameter 14 millimeters; figure 9, dorsal view of shell, carinorostral diameter 16 millimeters; figure 10, exterior of scutum, height 6 millimeters; figure 11, interior of scutum, height 6 millimeters; figure 12, side view of shell, height 9 millimeters; figure 13, dorsal view of largest shell, carinorostral diameter of orifice 13 millimeters. Figures 7, 8, 10, 11, Paratype CAS 13154; figure 9, Paratype CAS 13153; figure 12, Holotype UCMP 10184; figure 13, Paratype UCMP 10185.



interspersed; lower third of cutting edge with two large spines followed by about six smaller spines; inferior margin lined with a few long setae.

Maxilla II (fig. 25) with long, densely setose posterior lobe and short, rounded, sparsely setose anterior lobe.

Rami of *cirrus I* (fig. 26) unequal, densely setose; outer ramus about one-third again as long as inner ramus, curved posteriorly in opposite direction from all other rami, slightly protuberant in lower half, and tapering distally to slender tip, inner ramus protuberant in lower two-thirds, tapering distally to slender tip.

Rami of *cirrus II* (fig. 20) unequal, densely setose, strongly protuberant, short and thick outer ramus slightly longer than inner ramus; upper margins of articles lined with short bristles.

Rami of *cirrus III* (fig. 19) similar in structure to those of *cirrus II*, unequal, with outer ramus somewhat longer; all articles, except most distal bearing teeth on upper anterior and upper margins.

Cirri IV through VI with long, slender, subequal rami, differing in structure from *cirri I through III*; rami of *cirri IV and V* armed with teeth as in *cirrus III*; rami of *cirrus VI* (fig. 21) with a few small denticles along posterior part of upper margins of intermediate articles; intermediate articles of *cirri IV through VI* with three, four, or five pairs of spines on anterior margins.

Penis long, with setose basidorsal point (fig. 18); distal end bearing tuft of setae.

The number of articles per individual cirrus is as follows:

Holotype UCMP 10184: (right side)

Cirrus:	I	II	III	IV	V	VI
Outer ramus:	19	11	13	20	20	22
Inner ramus:	14	9	11	24	26	27

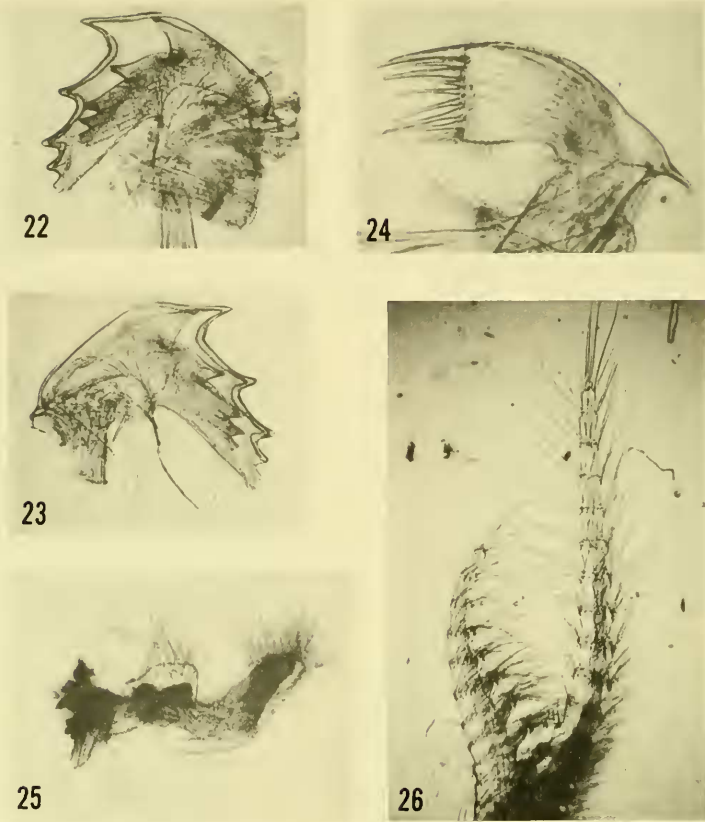
Paratype CAS 13154: (right side)

Cirrus:	I	II	III	IV	V	VI
Outer ramus:	19	12	12	27	33	38
Inner ramus:	14	10	13	30	37	40

OCURRENCE. University of California Museum of Paleontology, Berkeley (UCMP) locality B-4237, beach and nearshore intertidal on northeast side of Clipperton Island about 1 kilometer on either side of spot indicated as "landing place" on United States Navy Hydrographic Office Chart no. 1680.

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FIGURES 14-21. *Balanus tintinnabulum clippertonensis* Zullo, new subspecies, Holotype UCMP 10184, UCMP locality B-4237, Clipperton Island. Figure 14, mandible, × 40; figure 15, labrum, × 40; figure 16, palp, × 40; figure 17, maxilla I, × 40; figure 18, basidorsal point of penis, × 30; figure 19, Cirrus III, × 30; figure 20, Cirrus II, × 30; figure 21, Cirrus VI, × 30. (Prints by G Dallas Hanna.)



FIGURES 22-26. *Balanus tintinnabulum clippertonensis* Zullo, new subspecies, Paratype CAS 13154, UCMP locality B-4237, Clipperton Island. Figures 22-23, mandibles, $\times 30$; figure 24, maxilla I, $\times 40$; figure 25, maxilla II, $\times 30$; figure 26, Cirrus I, $\times 30$. (Prints by G Dallas Hanna.)

DISPOSITION OF TYPES. Holotype UCMP 10184, Paratype UCMP 10185, and referred specimens deposited in the University of California Museum of Paleontology, Berkeley. Paratypes CAS 13153 and CAS 13154 deposited in the Geology Type Collection of the California Academy of Sciences.

DISCUSSION. *Balanus tintinnabulum clippertonensis* closely resembles *B. tintinnabulum galapaganus* Pilsbry, 1916 in numerous respects, but a few, constant features serve to separate the Clipperton Island subspecies. The most evident characteristics are 1) the small, deep lateral depressor pit of the scutum, 2) the absence of an adductor ridge, 3) the absence of a fifth tooth on the cutting edge of the mandible. The scutum is narrower and the tergal spur shorter than those of most individuals of *B. tintinnabulum galapaganus*.

The Hawaiian *B. tintinnabulum tanagrae* Pilsbry, 1928, is also related to the Clipperton and Galápagos subspecies in its possession of a flattened scutum, but can be distinguished from both by the shorter (15 percent of the tergal height), broader tergal spur, and specifically from *B. tintinnabulum clippertonensis* by the large, open scutal depressor muscle pit bordered by an adductor ridge, and the presence of a conspicuous fifth tooth on the cutting edge of the mandible. The mouth parts and appendages of *B. tintinnabulum tanagrae* were not illustrated by Pilsbry (1928, p. 311). A slide of his "cotype no. 2416" in the collection of the Academy of Natural Sciences of Philadelphia was examined for comparison with the mouth parts of the Clipperton subspecies. The mandibles of this "cotype" are interesting in their possession of a small tooth between the first and second primary teeth of the cutting edge.

The three above-mentioned subspecies form a small insular group in the *B. tintinnabulum* series that is characterized by a flat scutum. None of the four described subspecies of *B. tintinnabulum* from the mainland coast of West America (namely *B. t. californicus* Pilsbry, 1916, *B. t. coccopoma* Darwin, 1854, *B. t. concinnus* Darwin, 1854, and *B. t. peninsularis* Pilsbry, 1916) appear to be closely related to this series, as in all the tergal side of the scutum is broadly reflected and an adductor ridge is developed.

The total lack of diversity in the Clipperton barnacle fauna is certainly perplexing. The paucity of barnacles and other sessile marine epifauna seen on oceanic islands of the Western Pacific has been discussed by Newman (1960) and Backus (1964), who attributed this phenomenon to intentional or inadvertent predation by rasping fish. Although there is no direct evidence of such activity from Clipperton Island, it is quite possible that rasping fish do limit the size and distribution of the *B. tintinnabulum clippertonensis* population. However, it is improbable that rasping fish could be responsible for the total absence of other species.

The reason is more likely biogeographic. The small size and isolation of Clipperton Island reduce possibilities of species immigration. Secondly, atoll environments are probably not conducive to successful colonization by the more common barnacles of the West American Panamic Province. Lastly, Indo-West Pacific barnacles adapted to atoll environments are either absent from island groups along the eastern border of the province (the border of the East Pacific Barrier of Ekman, 1953), or are considerably less diverse than in western parts of the province.

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